HIGH TECHNOLOGY VS. SELF-RELIANCE: BRAZIL ENTERS THE COMPUTER AGE[1]

Simon Schwartzman

Summary

1 Prepared for the M.I.T. Symposium on "The Computer Question in Brazil," Cambridge, Mass., April 16, 1985. This paper benefitted from conversations held with people at the *Centro Tecnológico de Informática*, SUCESU, IBM do Brasil, and other knowledgeable participants of the current developments in the computer field in Brazil. None of them are responsible for my understanding of what they said. I am grateful to Professor Peter H. Smith, Department of Political Science, M.I.T., for the invitation to write this text and present it at the Seminar. I am also indebted to Alexandre Barros, Claudio Moura Castro, and João Batista Araújo e Oliveira for criticizing a first version of this paper.

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By the end of 1984 a bill defining a "national policy for informatics"[3] was approved by the Brazilian Congress by a large majority of votes from government and the opposition parties. It was preceded by a lively debate reminiscent of the period before the setting up of the country's oil state monopoly and Petrobrás in the early fifties Once more the issue was presented as a dilemma between national autonomy and self-determination, on one hand, and control of the country's resources by international companies and their local associates on the other. Once more the campaign gathered intense support, from nationalist military groups to intellectuals and left-wing political parties.

It is remarkable that the Law of Informatics was approved in. the twilight of the military regime, when most of its ambitious projects of the Seventies had already proved monumental fiascos . The true extent and reasons for this disaster are still to be evaluated. The official line was to blame the oil shocks and high interest rates, which put the country's external debt and internal inflation almost out of control, and forced the implementation of recessive policies. But there were also over-ambitious projects, like the nuclear program, the "steel railroad" between Minas Gerais and Rio de Janeiro and the hydroelectric plants of Itaipu and Tucurui; unrealistic optimism, like the one surrounding the Carajás project; and sheer mismanagement and corruption, like in the naval industry program. All these elements played some part. The fact was that charges that the State bureaucracy's policies were wasteful, inefficient, and corrupt abounded and played an important role in the political change that led to Tancredo Neves' election to the presidency in early 1985.

The national "informatics" policy (we shall refer to it by the acronym PNI), however, was not affected. In spite of being a governmental project with strong military backing, it also had support in the academic community, and was presented as a purely national project based on private enterprise, making use of national competence and confronting the pressures of multinational interests. At the end, it drew opposition from the official candidate to the presidency, Paulo Maluf, who was already politically isolated, and support from his winning opponent. Thus, from a political standpoint, the "informatics" law was sone kind of paradox, and a remarkable political achievement .

In this article we try to show that this policy and the institutions it created are not an anomalous or extraordinary event in Brazil, but are well ingrained in the country's policy-making tradition. Nationalism, we will contend, is its most apparent feature, but not the most important one. Once we understand the origins of this policy, we can draw a picture of the main

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3 "Informatics" (as in French, "informatique") is the standard word utilized in Brazil to cover the whole field of computing, microelectronics, automation, etc.

actors involved in shaping it, how they act and what they have been able to achieve. With these elements, we might be able to speculate about the current strengths and weaknesses of PNI, the problems it may have and what one can expect about it in the near future .

1. Framework

The role of the State in promoting industrial development in Brazil has been a constant feature in the country's recent history, and has been subject to detailed scrutiny (see among others Leff, 1968; Martins, 1976; and Wirth, 1973). In some cases, this role has been exerted by the creation of companies owned and run as part of the state's administration, like the Volta Redonda steel mill in the Forties and Petrobras in the fifties. In many other instances, the government provided privileges and protection to private groups to run their own industries, creating fiscal barriers for competitive imports, providing special tax exemptions and credit facilities.

When the State gets involved in industrial promotion it affects not only the amount of goods produced and the distribution of wealth in society, but the country 's whole social and political fabric how interest groups are established, how class conflicts are carried on, how the political parties behave, and how government itself is organized and run (see for instance Gershenkron, 1962; Polanyi, 1957; and Bendix, 1956). An excellent framework to understand this complex reality has been recently proposed by Edson de Oliveira Nunes, who suggests that Brazilian politics and policy-making should be understood in terms of four different and shifting "grammars", namely clientelism, corporatism, bureaucratic insulation and procedural universalism (Nunes, 1984).

One could say, accordingly, that since the Thirties Brazilian industrialization and economic modernization have been promoted typically by administrative groups acting under bureaucratic insulation, as a protection against clientelist distributivism, or a way to assure control of some key resources against foreign or private interests. As a given policy develops, new actors are called in, and corporatist structures are put forward to discipline and control the interests involved. In a later stage, there are pressures to generalize access of different actors and interest groups to new fields of activity. In some cases, as in the development of the country’s automobile industry and other projects during the Kubitschek government, the policies were carried on by "executive groups" with full authority and working directly under presidential supervision. For the automobile industry, special benefits were provided for large multinational corporations to establish themselves in the country. Competition among the companies was regulated, nationalization targets for components were set, and salaries were controlled by the country's corporatist labor legislation. Entrance of new companies was not allowed (except later for Fiat, which accepted to get established in Minas Gerais and got strong backing from that state's government). A different example is oil production. Here, the policy of excluding private groups and foreign companies started in the Thirties, and resulted in the creation of Petrobrás in the Fifties, as a state-controlled company with legal monopoly over the oil industry. (Some residual place was left for private and foreign companies for refining and retail distribution, under close governmental control) .

Whether bureaucratic insulation leads to policies of one of those two types is neither trivial nor inconsequential. A prerequisite in both cases is the existence of an active group with political access which can get support at the highest possible levels, without going through the more traditional channels of clientelist politics which usually means to avoid Congress and the political parties. In some cases, this group comes from a more "modernized" sector of the State 's administration, including the armed forces. In others, it comes already with strong links with private, national or foreign interests, and acts as "bureaucratic rings" linking public and private interests. In the first stage of a new policy, the characteristics of this group are probably crucial

in determining its policy's content and orientations. At later stages, however, all will depend on its capacity to put forward its ideas, the other interests that get involved, and the whole political climate in which decisions are taken.

Here again the example of oil is interesting. In the Thirties Monteiro Lobato, a well known intellectual and entrepreneur, organized his own company to find oil in Brazil and drew the wrath of officials in government who wanted to keep oil extraction under state control. Lobato accused the administration of working in alliance with American companies to keep Brazil out of oil production, and tried to associate with German interests (later, he became a symbol of economic nationalism and is considered one of the forefathers of Petrobrás). It is possible to identify, behind these differences in policy, the clash of groups with different institutional and even regional origins[4]

Corporatism functions as a mechanism to define who should participate, and what benefits they should get from that participation. This expression is often used to characterize the relations between workers and employers in Brazil, which are minutely regulated by law and supervised by the State. Its scope, however, is much larger, including a wide range of special privileges granted to citizens with some specific qualifications (usually university diplomas) and benefits, subsidies and other forms of special treatment provided to some economic groups, in exchange for close governmental supervision and control .

Corporatism and bureaucratic insulation are useful to protect specific projects and institutions from political patronage and universalism. Few people are openly in favor of political patronage or clientelism, that is, the distribution of public jobs on strictly political grounds, with total disregard for the recipients' qualifications and entitlements. Universalism, however the notion that there should be no special monopolies and privileges, but open competition based on merit and competence is a much more legitimate stand. Bureaucratic insulation and corporatism can easily function as protections for inefficiency and privilege, hidden under the banners of patriotism or national security. In order to have competition, however, one should have competitors, and it certainly makes sense to try to build them up in the country instead of paying the price of opening it fully to foreign interests without appropriate restraints and controls.[5]

2. Origins: bureaucratic insulation

In the late Sixties Brazil started a large program for scientific and technological development with support from the National Development Bank (Banco Nacional de Desenvolvimento Economic). For the first time S&T was defined as part of the country's economic development strategy, and resources became available in much larger scale than ever before. Support was provided to research groups deemed competent with a minimum of bureaucratic complications and bypassing both the university administration (for academic groups) and peer review procedures. In hindsight, it is clear that this was a typical case of bureaucratic insulation. There was little coordination between this policy, carried through under

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4 It was not by chance that Lobato was from the state of São Paulo, the country's more dynamic economic center, while his opponents at the National Department of Mineral Production were mostly from Minas Gerais, a state with a weak private economy but a well reputed, and quite traditional, School of Mines. See Schwartzman and Castro, 1985, and Carvalho, 1979.

5 I will take for granted, throughout this text, that it is preferable to have the whole computer industry's productive cycle in the country than to rely only on imported equipment based on unknown "black boxes" There are enough economic, political and cultural arguments for this preference which need not be repeated here. The problems to be analyzed are not related to its desirability but to its feasibility and costs.

the umbrella of the Ministry of Planning, and the economic and industrial policies that took place under other Ministers with different orientations.

Insulation from clientelism, bureaucracy, and short-term economic pressures was indispensable to provide space, time and conditions for scientific and technological research to flourish. Research groups need to be exposed to the larger scientific community, on one hand, and to possibilities of applications, on the other, in order not to get sterilized. Scientific exposure is a constant demand of high quality research groups, and it was possible to provide them with the resources for that. The results are quite impressive. Although small by international standards, the Brazilian scientific and technological community is today the largest in any developing country after India (Schwartzman, 1978 and 1979; Castro, 1985). It has about 20 thousand professional researchers, and about one thou sand graduate programs in all fields of knowledge. Extensive fellowship programs allowed thousands of graduate students to go to the best universities in the United States and Europe, and they have usually found places to work upon their return. Quality is uneven, and in the last few years there has been a tendency to divert scarce resources towards politically protected, low quality groups in peripheral universities. However, the best graduate and research institutions are of first quality.

Practical economic results coming from all this in vestment have been limited, but it would be misleading to at tribute it to some kind of ivory tower attitude. Investments were made in engineering, solid-state physics, tropical medicine, agricultural research and other fields with potential practical usage. However, industrial policy not always favored the utilization and growth of this potential, and scientists, mostly in the technological fields, have always felt bitter about the waste of their energy and intellectual capacity[6].

Computer science and electronics were among the fields developed under these conditions, and a new, nationalist policy for informatics provided them with an opportunity most other areas did not have.[7] In the early Seventies the Brazilian Navy was operating its ships using English Ferranti computers, and wanted to support a program to develop the country's capability to build its own data-processing equipment. There was a question of national security involved, which became thereafter a central justification for the national computer policy. A pilot project started with Navy's support involving the School of Engineering of the University of São Paulo, which had the competence to work on hardware, and the computer group of the Catholic University of Rio de Janeiro, working on software. The first Brazilian computer, the *Patinho Feio* (Ugly Duckling), came to light after some time, and two prototypes of an improved version, the G-10, existed in the two universities in early 1976. *Cobra*, a state-controlled company, was organized in 1975 to produce the G-10 industrially. However, its first
option was to assemble computers using Ferranti (English) and Sycor (American) technology, with the understanding that this technology would be fully incorporated by the Brazilians. The Brazilian prototypes were left for research work. A holding company for the computer industry, *Digibrás*, was also established, as well as a supervising governmental agency, CAPRE, under the Ministry of Planning. From CAPRE emerged the initial steps of a nationalistic policy which included a few basic principles: to create a group of 100% nationally owned companies which

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6 The example of COPPE, the graduate engineering program of the Federal University of Rio de Janeiro is striking. Its ambition was to cover the full range of modern technologies, including nuclear, chemical, electronic and naval engineering. However successful it has been in comparison with other engineering schools in Latin America, it soon became clear to COPPE leaders that they had become much more competent than what the country's industry could absorb. Cf. Nunes, Silva and Schwartzman, 1982. At the opposite end, agricultural researchers like to emphasize the economic returns of their work, in terms of yields and profits generated by new technologies.

7 The involvement of the scientific community with the computer policy should be seen in contrast with its alienation towards the Brazilian nuclear program, which is exactly the opposite to what happened in Argentina. These parallels are made explicit by Adler, 1985.

could develop their own technology or purchase it from abroad, and only to accept foreign cooperation with arrangements for full technological disclosure (Adler, forthcoming).

A crucial decision was about which segment of the computer industry Brazilian firms could occupy. The field of large, all purpose mainframes was already taken by IBM, Burroughs and other international companies, and it was out of question. These were the years before the micro-computer revolution, and the decision was to go for the minicomputer industry. In 1976 IBM announced in Brazil a small computer system, called /32, in what was considered a preemptive move to occupy this market's segment. The protracted dispute between IBM and CAPRE, in the next two years, led to the establishment of an import licensing policy for computer equipments which required, among other things, an association between foreign and Brazilian firms, and growing indexes of nationalization. In late 1977 CAPRE decided to authorize three Brazilian companies to produce minicomputers with technical assistance agreements with foreign associates, and to the exclusion of IBM, Burroughs and Control Data (Silvia Helena, 1984).

In 1979 the Brazilian government issued an official document setting up the National Policy for Informatics (PNI), wich included the concept of a market reserve for micro and minicomputers for Brazilian companies. It also replaced CAPRE by the *Secretaria Nacional de Informática*, SEI, as an agency under the National Security Council. As part of the military intelligence establishment in an authoritarian regime, SEI's power was almost unlimited. It controlled imports, intervened in the creation of new industries, in the organization of data processing centers in companies and universities, and in the granting of federal subsidies to private firms. It could and it did interfere in all branches of government having to do with data processing, which means all of them. This power concentration was perceived as incompatible with the democratic regime that was to start in 1985, and that is why SEI needed a legal mandate, which was granted by Congress at the end of 1984.

3. Growth: corporatism

As stated earlier, the involvement of university departments in the early days of the computer policy provided it with strong ties with the university community, which was very helpful in providing it with technical competence and legitimation. Several among these academics later created their own computer companies, which benefitted from the public support and privileges they helped to create. CAPRE's replacement by SEI generated tensions between this group and many newcomers to the field, some of them coming from the military intelligence and with little knowledge or trust in previous CAPRE leadership. These tensions were later reduced through better knowledge and change of some actors. This reduction was helped by the fact that most of the military officers involved with PNI had also been trained in the field, and were therefore able to relate intelligently with the academic community and to reinforce an image of competence and efficiency. They came from the more technical sectors or the Brazilian Navy and military educational institutions the Instituto Militar de Engenharia (IME) in Rio and the Instituto Tecnológico da Aeronáutica (ITA) in São Paulo, and many of them have been trained abroad.[8] A lobby composed of academics, officers, entrepreneurs, students and computer professionals was developed and played a very active role in shaping PNI.

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8 ITA's presence is particularly significant. It was organized in the Forties as an engineering school run by the Brazilian Air Force and became the country 's leading engineering school, open to civilians through nationwide entrance examinations. Around ITA developed the São José dos Campos industrial and technological complex, where the country 's most sophisticated techno- logical institutions are located, including the Instituto de Pesquisas

Brazilian firms, which in 1978 produced only 2% of the total installed value in computer equipment, had moved to 19% in 1982. In the micro and mini class, however, Brazilian firms went from 17% to 80% of the market, which had increased fourfold in these four years. Comparisons between the national and multinational sectors of the computer industry in Brazil show that they have similar sizes, with the multinational sector being more capital intensive, doing less R&D and selling slightly more than the Brazilian one (table 1).

This change occurred not only because of policy decisions, but also thanks to the micro-computer revolution, which opened new opportunities for the Brazilian computer industry. For the first time, it was possible for small firms to assemble computer equipment through the utilization of off-the-shelf components, and the technical competence needed for that was well within the reach of the Brazilian electronics industry. In 1983 there were about 54 Brazilian computer manufacturers, of which only 11 existed prior to 1974; 25 where created after 1978. These firms started producing "clones" of Sinclair, TRS, and Apple computers, mostly with copied software and operational systems. Peripherals were also produced or assembled in the country printers, modems, terminals, videos. Adaptations had to be made in software and keyboards for the introduction of Portuguese language and special graphic signs.

There are at least three main types of Brazilian computer manufacturers. First, there are the state-owned corporations. The most important is *Cobra,* responsible for about 25% of the capital, 16% of the sales and 12% of the manpower of the Brazilian sector.[9] According to international standards, however, it is not a large firm: *Cobra*'s capital for 1983 was only around 15 billion cruzeiros (US$ 15m) . Its capital was formed mostly with public funds, and for several years it was troubled with problems of low performance and reluctance of private shareholders to increase their investment levels. It concentrates on the segment of mini and mid-size computers, and is showing signs of improvement in the last few years. A special place is taken by *Prólogo S/A*, a subsidiary of *Industria de Material Bélico do Brasil (Imbel),* the Brazilian state owned armaments manufacturer. It is a company meant to serve the computer needs of the country's intelligence agencies and the military. It was created in 1980 by a presidential decree, with a mandate to work in the fields of communications security and cryptotechnolegy. Today, according to *Jornal do Brasil*, *Imbel*'s production ranges from the production of sophisticated military equipments to civilian versions of banking computerization and control, and is moving into the production of robots with technology acquired from Asea AB, a Swedish firm. *Prólogo* is located in Brasilia, employs 450 people, and is said to be wholly self-sufficient economically (*Jornal do Brasil*, February 25, 1985)[10]

Table 1: Comparisons between Brazilian and multinational computer firms (1983)

	national firms	multinational firms
Total sold (US$m)	687	800
total employed	15734	10010
total employed in hardware/ software development	1117	121
number of employees with university degrees	3888	2 , 810

Espaciais, EMBRAER and many private companies. ITA's alumni also helped to build in the University of Campinas one of the best physics department in the country.

9 Cobra's capital was formed with resources from state companies - SERPRO, Banco do Brazil, Caixa Econômica Federal, BNDE and Digibrás (56%), a pool of national private banks (39%), and E. E. Equipamentos Eletrônicos (Brazilian) and Ferranti (English) with the last 5%. (Cf. Tigre, 1982, p. 114-5). A full account of Cobra's history is given in a forthcoming book by R. Ramamurti (1985).

10 Working under secrecy, Prólogo is an extreme case of bureaucratic insulation, and there is no way to assess whether its claims of efficiency and self-sufficiency are correct. Based on experiences of other secretive operations in Brazil, one would usually expect the opposite (I am grateful to Alexandre Barros to calling attention to this point).

number of employees with university degrees per 100 million dollars sold	566	351
number of employees with university degrees per 100 million dollars of equipment installed	54	8
million dollars imported	49	179
imports/total sold	7 , 1%	22,4%
Source: SEI, 1984.		

Secondly, there are companies formed by individual entrepreneurs coming from the university and other areas. The most quoted example is *Scopus* in São Paulo, which produces among other things an IBM-PC equivalent, Nexus, and has been compared with Apple for its style (although not, certainly, for its size). Other companies have developed from small electronics and engineering firms.

Finally, and more recently, come the companies linked to the banking system. These companies, quite understandably, are those that are growing more intensively. The best examples are, probably, *Itau Tecnologia*, controlled by Itau Bank, the second largest in the country, and *SID Informática*, controlled by the Mathias Machine group, 18% of which belongs to Banco Bradesco, the country's largest bank. Itau, which was already the 4th company in the ranking in terms of capital in 1983, was expected to come first and above *Cobra* in 1984, with a staff of 1,600. Two other companies to produce electronic components *(Itaucomp*) and printed circuits (this one in Manaus) were also established by Itau in 1984. SID sold in 1983 about twelve thousand units of equipment and increased its working staff from 800 to 1,200, and invests 7% of its sales in R&D. Other fast-growing industries include *Edisa*, with 325 systems sold in 1983 and in 14th place in the ranking; and *Dismac*, with 2,000 micros sold in 1984 (as against 1,500 in 1983) and about 1 US$ million a year in R&D (*O Globo*, December 31, 1984).

The rapid growth of the computer field and the press coverage it receives helped to make it one of the most prestigious careers in the country's universities and technical schools. For the unified entrance examinations to the universities in Rio de Janeiro for 1985 there were about 18 candidates for each place in courses related to computer sciences. The number of candidates for these courses increased by 420% in four years. (*Jornal do Brasil*, November 23 and 24, 1984). No figures were given for the total number of places available. However, computer sciences (or informatics, in Brazilian terminology) is placed within mathematics, for which there were about 10 thousand candidates for about 1,000 places (The average ratio for all areas was 3.4). The picture for the state of São Paulo is similar.

This demand is related to a movement for the creation of a protected labor market for professionals in the field of computer sciences and data processing. They are already organized in the *Associação de Profissionais de Processamento de Dados* (APPD) which has been very active in promoting legislation to protect its slice of the labor market. The notion that, to each field of knowledge, should correspond a university degree, a legally protected profession and a slice of the employment market with guaranteed salaries, is part of Brazil's corporatist tradition and is extremely ingrained in the country's culture and legislation. Legally defined professions today include not only Engineering, Law and Medicine, but also Administration, Statistics, Journalism, Psychology, Pharmacy, Biology, Economics, Archeology, Nursery, Social Work, and so forth. There is a bill being examined by Congress creating a Federal Council of Professionals in Electronic Data Processing. This council, differently from the traditional corporations of medical doctors, lawyers or engineers, would include from terminal operators to system analysts. The new council would control the entrance requirements to jobs performing these activities and see that their working conditions and salary levels are those defined by law. Senator Roberto Campos points out that the use of computers is becoming a personal routine for professionals in all fields, but this law, if approved, would restrict its use for those accredited

before that federal council. Since Campos is well-known for his strong opposition to SEI and all its policies, his criticism against this bill is likely to be discounted as just another one of his attacks. The Brazilian tradition is to approve this type of legislation for all kinds of quasi-professions, and it is not unlikely that, Campos' good arguments notwithstanding, it will happen again.

There is nothing so far in terms of regulation for software, probably because it is so much more difficult to control its imports, and also because of obvious conflicts of interest. Most manufacturers try to make their equipment as compatible as possible with software available in the international market, while software producers would rather have the equipment restricted to national programs, which could be sold for high prices. Some manufacturers have opted for equipment that only works with their own software and vice-versa, leading to expensive products with limited sales. There are plans to adopt UNIX as a common operational system for the Brazilian computer industry, a set of national standards and the introduction of new, advanced technologies for software production. All this, however, is still at the planning stage. Public domain software are non-existent and not planned for; smuggling and illegal copying, however, are widespread.

One could sum up by saying that the field of computer production and operation is being organized in Brazil according to the views and interests of its promoters, producers and professionals, and that this organization follows the usual pattern of corporatist regulation and protection. How long this tendency will hold depend on their capacity to confront three challenges: the changes in the political system, which threatens bureaucratic insulation; the pressures of a growing user's market, which requires quality, services and low prices; and the pressures of international competition, which looms behind the market's pressure in its demand for universalism. Success will depend, in part, on political variables; but it will also depend on the computer industry's capacity to step up its research effort and respond effectively to the internal demands and foreign competition.

4. First challenge: users

The existence of a nationalized industry and a protected labor force in data processing supposes a significant number of users at the receiving end. The computer market in Brazil has been well analyzed by researchers from the Instituto de Economia Industrial in Rio de Janeiro (Tigre, Erber, Piragibe), and we shall only give a brief summary here.

The new computer policy started when computer usage was already well established and a fairly large market for imported equipment existed in many governmental agencies, universities, banks, and companies. In 1976 there were about 5,000 computers in the country, of which 172 were considered "large" or "very large", and 3,300 "mini" (Marques, ABICOMP 84, p. 18). In terms of value, the segment of large equipments ("mid-size" and above) corresponded to about 1,000 million dollars in 1976, as against 144 million dollars for the micro and minis. The total value increased from US$ 1,235m in 1978 to US$ 2,777m in 1982 (Erber, 1985).

In 1981 about 25% of the computers in the country were installed in banks, 13% in service bureaus and the rest scattered among different types of industry and public utilities (SEI, quoted by Erber, 1985). This information ignores, of course, the widely different capacities of the equipments. The Brazilian government is one of the largest computer users in the country. It owns the largest service, Serpro, which handles among other things the income tax data processing. Other large users are Dataprev, the data processing company from the social security system and the IBGE (the census bureau). Besides, there are computer systems in all large state-owned and state-controlled companies, including the public utilities (water telephone and

electricity) and state-owned banks. Most universities have their own computer centers. The country's main airports, banks, and airlines are becoming fully computerized.

Table 2 - Characteristics of the Brazilian computer industry, 1983	
Number of firms	54
Total capital:	58
maximal growth 1982/3	141%
Concentration of sales: largest (COBRA)	25,4%
2nd largest	365
10th largest	784
% of sales: microcomputers	280
minicomputers	441
peripherals	180
other components	99
total	100%
Geographical concentration of sales: State of S. Paulo	46,4%
State of Rio de Janeiro	264
Rio Grande do Sul	53
Brasilia	52
4 regions	83,3%
Geographical concentration of production: State of S. Paulo	67.8%
State of Rio de Janeiro	214
Rio Grande do Sul	84
Others	24
Type of buyers: Government	9,0%
Commerce	168
Industry	282
Financial sector	300
Services	156
Total	100%
Employees: priority education	21,2%
secondary	50,1%
higher	287
Total	100% (N::15,734
Activities of employees with higher education:	
sales, marketing	19,7%
administration	259
production	143
technical assistance	120
product development	247
training	3
Expenditures on software:	
in-house	89,5%
software houses	30
universities	38
foreign supplier	9
Source: SEI, 1984.	

A market is also emerging for personal computers. From 150 to 200 thousand personal computers were sold in Brazil in the last few years. Most are of the Timex type, costing between one and two hundred dollars; Apple and TRS clones also exist. A survey among users of home-computers in the São Paulo area showed that they are mainly young people (21% less than 19 years, 22% between 19 and 25, only 27% more than 36), and mostly for videogames (33%). Other uses are: data banks and accounting, 31%; word processing, 12%; graphics, 11%; domestic chores, 15%; education, 15%. The average use is 14 hours a week, as against 12 hours in the United States (*Veja,* December 19, 1984).

It should be noted that these are not necessarily Brazilian-made computers; notwithstanding the government's ban, smuggled micros are fairly easy to buy, and are openly advertised in the newspapers. In fact, the main users of Nacional equipment are not home users or independent professionals, but the financial and commercial sectors (table 2). On the whole, the market is heavily biased towards large, institutional users, and one can say that the micro-computer is still far from becoming an item of mass consumption in Brazil. IBM-PC alikes now appearing are geared towards small and medium-sized firms. Their price is high, they come already with expensive add-ons, and are supposed to be operated by professionals in data processing. Computer shops have not developed very much, and the few computer magazines that exist tend to be loaded with technical jargon, difficult to understand and of little relevance to the non-specialized user. There has been very little done in terms of "user-friendly" software and equipment except what is copied from Apple, and this expression, or its equivalent, is still to appear in the Brazilian computer industry.

For specialists in hardware architecture or software development, a protected market for their activity is considered crucial. For users, either of large mainframes or of personal equipment, what matters is price, reliability, good software technical assistance and simplicity for the non-specialist, and the Brazilian products and firms are not necessarily the best from this standpoint[11]. On the other hand, internal supply of software and equipment is a matter of concern for governmental agencies not willing te depend on external norms, regulations, and conveniences.

Manufacturers requiring electronic components in their products are another important client and potential source of difficulties. The recent history of Brazil's TV industry is fresh in memory. A few years ago, there were several Brazilian industries working with local technologies, located mostly in São Paulo. Now they have been wiped out from the market by firms working out of Manaus, up the Amazon River. Manaus is a Free Zone which provides special favors mostly fiscal exemptions and import privileges for manufacturers willing te get established there. Its electronic industry produces video-recorders, TV sets, electronic cameras, calculators, microwave ovens and just about all other consumer goods that rely on imported electronic components. There is now a dispute between SEI and the Manaus authorities for the establishment of computer manufactures in the region. It is a conflict with regional implications, since the national computer industry is mostly located in São Paulo, while the Free Zone is basically a mechanism te attract national and multinational industries to the Amazon area.[12]

Manufacturers of electric and electronic products have their own association, the *Associação Brasileira de Indústria Elétrica e Eletrônica* (ABINEE) which includes Brazilian and foreign firms, and is against any restriction on the imports of electronic components (Brazilian manufacturers working under SEI' s protection belong to another association, ABICOMP). There is also a very active *Sociedade de Usuários de Computadores e Equipamentos Subsidiários* (SUCESU), which works as a lobby for users, 70% of which have IBM equipment SUCESU has about 1,800 firms affiliated, and its own estimate is that it covers 50% of the Brazilian firms with computer installations or services.

In the long run, what will happen with the Brazilian computer policy will depend on its ability te respond reasonably to these demands, and to fellow them as they change. If it responds

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11 Complaints about the lack of technical assistance and support are widespread among users of Brazilian equipment, which explains the preference enjoyed among large users by IBM.

12 The establishment of microcomputer manufacturers in Manaus can force all other firms to move there to remain competitive. The free trade zone authority, SUFRAMA, is not committed to policies of technological transfer, and this can press the national industries there to give preference to imported, rather than to nationally produced components, exactly as it happened with the TV and sound equipment industries.

very slowly or inefficiently, pressure will mount to open the country still further te foreign firms and imported equipment SUCESU's president, Hélio Azevedo, sees a gradient of interests going from scientists to industrialists, computer professionals, users, and the population at large. For him, the weight so far has been on the scientists' and industrialists' side. As the pendulum moves to the other extreme, he predicts a "Copernican revolution" to happen in the Brazilian computer environment. Much of what will happen will depend on the second challenge PNI has te face, that is, research.

5. Second challenge: research

It is clear to all involved in PNI that it cannot be sustained for long based only on SEI's authority and nationalist ideals, if it cannot keep up with the technological challenges of the field. The pressure for universalism, that is, free market will grow almost irresistibly, opening the way for foreign technology and companies. Early in 1985 an integrated, three-year research plan in computer sciences was put forward by the *Sociedade Brasileira de Computação* and the *Instituto de Computação* of the *Centro Tecnológico de Informática*. The plan starts with the assertion that the national computer industry, created by professionals coming from universities, is today more advanced technologically than the university system, except perhaps in a few basic areas. Its objective is to go beyond the industry's current capabilities, and open the way for further progress.

The plan provides a brief picture cf the current stage cf university research in computer sciences (which does not include related fields such as electronics or automation). There are five institutions providing doctoral degrees for ten persons a year (an average of two per institution). The total number of researchers with doctoral degrees is 108. There are also fifteen institutions providing master's degrees, and a small flux of people being trained abroad and returning to the country. On average, fifteen new doctors enter the field each year. The total number of researchers is estimated at 750, 500 of whom work on software The research plan projects an increase in the total number of doctors to 500 by the end of 1997, as against 300 if the current growth rate is kept. For this, it will be necessary to create new doctoral programs and provide more fellowships for studies abroad. Proportional increases in technical personnel, equipment, library facilities, etc., will also be needed. The total cost for research projects, infrastructure, interchange and follow-up is estimated to be around 40 million dollars in three years. This value is placed in comparison with figures of R&D expenditures in computer science of developed countries: US$ 500m for the "5th generation project" in Japan, 350 million pounds in five years in the United Kingdom, US$ 220m a year for the "Esprit" program in the European Community, US$ 400m for the "Stars" program and US$ 50m a year for the Microelectronics and Computer Technology Corporation, both in the United States. The amount required by the plan is quite small by international standards. However, Brazil would not have the capacity to absorb a much larger sum, given the current small basis of computer research. And even these limited resources may be very difficult to get.

A list of high priority research fields was also drawn. It includes the architecture of digital systems; time-sharing systems; software engineering; data bases; CAD/CAM; artificial intelligence; sign processing and pattern identification; mathematics applied to computing; and computer theory. In all, 65 projects were identified. The research plan can be understood essentially as an aggregation of isolated projects, to which a weak order of priorities was attached. The plan does not refer to research done at the private sector, to the activities of the Centro Tecnológico da Informática, or to the contribution of IBM to university research.

The research effort in the private sector can only be gauged by indirect figures. Brazilian computer firms employ about ten times more people in R&D than the multinational ones (1,177 against 121 in 1983), in spite of being smaller (these figures can be inflated, however, since the concept of research can easily be stretched when a company considers it convenient to do so). Work is done in reverse engineering, software adaptation, and new developments. The number of employees with higher education degrees per US$ l00m sold is almost twice in the Brazilian firms (566 against 351), and more than ten times in terms of R&D (171 vs. 15). There are no figures of R&D expenditures in the private sector. If one assumed that 5% of total sales go to R&D, this would give a figure of US$ 34m a year in R&D in the national computer industry. This figure, however, seems to be too high in terms of the available manpower.

The Centro Tecnológico da Informática was established in 1982 as part of SEI and transformed into the main sponsoring agency for R&D in informatics in the country by the 1984 law. In spite of its wide mandate, it is still a small outfit. It has about 300 people in its staff, working in the outskirts of the city of Campinas, São Paulo, divided among four institutes: automation, computation, instrumentation and. microelectronics. It is not a purely research institution: it sells services to the private sector, provides technical assistance and develops joint projects with the universities. As SEI's technical branch, it oversees the fulfillment of nationalization targets of IBM's computer assembly plant nearby and seeks to establish standards and provide certifications for the national computer industry.

The Computing Institute is, among other things, engaged in an ambitious program to develop a "software plant project" which would, according to its leaders, be able to place Brazil at the international frontier in terms of software development. A "software plant" is supposed to be an environment for software production endowed with an array of programming tools and automation mechanisms allowing to go from the typical 3-6 lines an hour of software production to the 10-15 level, and with better reliability. The Microelectronics Institute is basically concerned with technologies related to microchip production. There is no attempt to compete :internationally in terms of large-scale integration. However, the idea is that there is room for the development of custom-oriented ICs, and for some work to be done in all stages of IC production - project elaboration, masks, diffusion, encapsulation and quality control. One of the Instrumentation Institute's projects is to develop mechanisms of digital information processing and display which could be used with widely different sensors, thus providing the scale for instruments production the Brazilian market lacks. The Automation Institute works in the fields of linear and digital automated processes, seeking constant involvement with the industrial sector.

CTI's current budget is about US$ 1m a year, and a projected increase to US$ 3m is still to be approved. Its new mandate requires a much larger budget, but there is no assurance that these resources will be forthcoming. CTI's general director, José Rubens Dória Porto, was appointed as SEI's Secretário by the Tancredo Neves government, which assures a central place for CTI. However, the general policy of budgetary restraint does not favor any dramatic increase of resources for this or any other field in the near future, and, for the first time, SEI will have to dispute resources with other agencies within the Ministry of Science and Technology.

IBM is a relatively new, but potentially heavy newcomer to R&D support in Brazil. In the past, it provided the Catholic University of Rio de Janeiro with hardware and assistance, helping it to become the first and probably the best computer science department in the country. More recently, however, it did not match CDC's offer for a new mainframe to the Catholic University, and lost that special relationship. Now, according to an IBM spokesman, the company expects to provide equipment and support to 18 among the best universities and research centers in Brazil during the next four years, spending about 40 million dollars in equipment, software, technical assistance and fellowships. The beneficiaries include the School of Engineering of the State University of São Paulo, the Laboratório de Computação Científica

of the National Research Council and the Federal Universities of Rio de Janeiro and Pernambuco. Other support activities from IBM include about 20 fellowships for graduate students in the country and three for post-graduate studies in IBM laboratories in the U.S. every year; a Software Institute for teaching in software engineering; a Latin American institute for system analysis (LASTRI) which provide courses for IBM and non-IBM personnel; and a Scientific Center in Brasilia with about ten researchers at the doctoral level, working in applications in the fields of energy, administration, economics and health, in association with EMBRAPA (agricultural research), IPE (space research) and other institutions. IBM provides also technical assistance to Brazilian suppliers to its factory in Campinas, which exports around US$ 200m a year in equipment to many countries[13].

The Brazilian research effort is still very limited in size, and will have to increase quite considerably if the ambitions of PNI are to be met. Besides, tensions among these different research programs and support lines are likely to happen. There is a dispute between CTI and several university departments about their respective roles in R&D. For some departments, CTI is diverting resources from the universities and occupying fields which are not adequate for a government research outfit. For CTI, university research institutes should not provide services to industry, a role more properly performed by CTI. CTI defines itself as a privileged interface between the universities and industry, a role resented by some university departments.

The growing presence of IBM also generates tensions. The research plan organized by CTI and SBC contemplates only the incorporation of nationally produced hardware in the universities and it is clear that SEI does not appreciate the spreading of "IBM culture" and equipment. On the other hand, university departments using computers as research and teaching tools are happy to receive this support. It seems obvious that IBM seeks to stimulate applications of computer equipment in its own terms, therefore making itself indispensable. Changes or improvements of computer plants in the universities have to receive SEI's approval, which means that IBM's activities are closely supervised and attrition is bound to occur. At the same time, there will be no match for IBM if she really goes ahead with its plans to equip the universities at no cost.

6. Third challenge: politics

Whether SEI will be able to keep its authority, and whether research money will be forthcoming to CTI and the universities, it all depends on politics. Bureaucratic insulation is being challenged not only by external competition, pressures from the users and the speed of technological innovations, but also by the changing political climate which makes bureaucratic insulation much more difficult to keep today than in the near past.

The Bill institutionalizing PNI was send to Congress by the Brazilian government in June, 1984.[14] The text, among other things, defined the general objectives of the new policy, established a National Council for Informatics and Automation (CONIN) and defined the scope and authority of the *Secretaria Especial de Informática* (SEI). SEI was empowered to examine in advance all import requests for goods and services related to informatics for 8 years. The law

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13 The participation of Brazilian employees and suppliers in its Campinas factory is a big item of IBM institutional publicity in Brazil. However, there is no publicity about its support for R&D, for cautionary or some other unknown reason.

14 According to the country's authoritarian constitution still in place, a bill coming from the Executive has to be voted by Congress within a pre-defined period, or it is automatically enacted.

also authorized the creation of a research agency, the *Fundação Centro Tecnológico para a Informática* - CTI and a special fund for informatics and automation.

Many things changed between the first text and the version approved by Congress, which, throughout 1984, acquired increasing autonomy from the Executive. Originally, CONIN and SEI were to remain under the National Security Council. In the final version, CONIN came directly under the President, side by side with the Councils for Social and Economic Development, the National Information Service (SNI), the Armed Forces High Command (EMFA), and the National Security Council itself (in comparison, the National Research Council remained within the Ministry of Planning, in a much lower position). More significantly, CONIN and SEI were taken away from military jurisdiction. Now the *Secretaria de Informática* (SEI) was to be controlled by a collegiate body, and placed under a non-specified Minister. In the new government, this is the newly created Ministry of Science and Technology.

Further changes were introduced by the Executive, which enacted the bill with a few vetoes on October 29, 1984. On December 27 the President issued a "decree-law"[15] changing some items of the original text and three decrees regulating the law's implementation. The vetoes killed two amendments made by Congress dealing with protection of citizen's rights to privacy and employment, as they could be affected by the new technologies. Also, it eliminated a tax which would provide the newly created fund for informatics with sizeable resources for research and development. Finally, they left open the number of members of CONIN, a decision which was perceived as a door to give it a majority of military officers. The decree-law changed the original definition of "national companies" to include those with open capital but with 70% of it (or 2/3 of the voting shares) in hands of Brazilian residents, public corporations or companies. It also subjected any change of the control in these companies to governmental approval. The aim was to make room for banks and other companies with publicly traded stocks; one of its consequences is, of course, to open the door for non-controlling foreign capital.

The first decree has an extremely detailed definition of CONIN 's attributions. Its mandate runs along 32 items, from the elaboration of a National Plan for Informatics and Automation to the establishment of technical norms, control of international data transfers, evaluation of teaching programs for professional training, creation of research centers in the country and abroad, approval of projects of technological transfer and of capital increases in companies. It has also a say in matters of import and export policies.

All this wide range power is diluted, however, by the way the Council is to be organized and run. Of its 22 members, 14 are Ministers, 8 are chosen from lists presented by interest groups related with informatics (users' associations, computer companies, professional and scientific societies, etc.). Even the Bar Association was contemplated, presumably for its concern with the citizen's individual rights. This format not only guarantees the government's control over CONIN, but also that its meetings will be made up mostly by the Ministers' deputies with usually no knowledge of the subjects under discussion and no autonomous decision power Besides, the Council is supposed to meet only once every two months, and the members are not allowed to request time to examine the documents under discussion (article 5). Still more significantly, two presidential vetoes (to article 7, III and 8, V) limited CONIN's power to make decisions, making it a predominantly normative and advisory body and leaving all practical power to SEI. With this structure, CONIN is bound to become essentially a legitimizing and rubber-stamp institution.

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15 "Decree laws" are another instrument of authoritarian power. Through them, the President can legislate by decree and "ad referendum" from Congress, which has 90 days and needs a majority of 2/3 to reject them The current Brazilian government has decided not to make use of Decree Laws before they are banned by the country's future constitution. as it is expected.

According to the second decree, SEI is supposed to be subordinated to CONIN and act as its executive agency. All CONIN's decisions are to be previously prepared by SEI; besides, it keeps its role of analyzing and approving projects of development and production of computer goods and a previous say on all imports related with the computer industry for eight years from the approval of the law in 1984. SEI runs a special *Fundo para Atividades de Informática* (FAI), has financial and administrative autonomy and is led by a powerful Secretário with supporting staff and sub-secretaries. The *Secretário* is appointed by the President upon recommendation of the Minister in charge of CONIN.

The last decree approves the by-laws of the *Fundação Centro Tecnológico de Informática* which was created by the law as an outgrowth of the *Centro Tecnológico de Informática*. The *Fundação* is to be a state-owned institution that runs according to private law with wide autonomy to hire and dismiss personnel, set salaries and manage its own resources. CTI is entitled, among other things, to create new entities in Brazil or abroad, sign contracts with universities and research centers, and make loans in the country or abroad. It has its own institutes and a complex administrative structure run by a president nominated by the President of the Republic. It does not report to SEI 's secretary, but directly to CONIN and to the Minister in charge of informatics

In many respects, these decrees are being interpreted by observers as a last-minute attempt of the Figueiredo government to reverse the intention be hind the changes introduced by the Congress, aimed at reducing SEI's power by making it a mere executive agency of CONIN, with limited policy-making authority. According to this view, the support SEI received from the Democratic Alliance (the political coalition which elected Tancredo Neves) cannot be taken as an unqualified endorsement, but resulted from a political understanding between Neves and a more militant group in his own party which was reluctant to agree with his election by an electoral college. CONIN was meant to be transformed into a meeting ground for different interest groups (including the different ministries in a coalition government), which would reduce what was perceived as SEI 's one-sided commitment with national producers of computing equipment.

It is still too early to say what will happen in the new government. The presidential vetoes can be reversed by Congress, and the new government can change the decrees. The nomination of Dória Porto as SEI's Secretary means that there will be continuity with PNI's general philosophy. At the same time, SEI's placement under the newly created Ministry of Science and Technology reduces its power and political access which is compounded by the political weakness of the new Ministry, due to problems related with the illness and final death of Tancredo Neves. This Ministry is already flooded with pressures for research money coming from all sectors, and clientelistic demands are bound to increase, while money is expected to remain short for everybody. External pressures are also likely to increase. Brazil will have to negotiate its debt with foreign creditors, who in the past have used the opportunity to press against the computer market protection, and can be expected to do it again.

7. Prospects: the birth of an industry or a "technological window"?

The official and more commonly held justification of PNI is that this is a necessary stage in the beginning of any self-sustained industrial development. According to this reasoning, national industries should be protected for some time from external, more mature competition, while they gather strength. The Brazilian history of import substitution in the industrial sector is said to confirm this. There is certainly a learning process expressed by the increasing sophistication, nationalization and low cost of the computer equipment being produced by

national companies. It should be noted, however, that this is the first time in the country's history that a segment of the private industry is closed to foreign companies, either alone or in association with Brazilian firms. All previous experiences of market protection were aimed at Brazilian made products (such as cars, appliances, and other electric products), not companies, except in state-controlled areas such as oil or telecommunications. In this sense, the current policy for computers is not comparable with previous experiences.

It is possible to argue, moreover, that what appears to be the initial stage of an emerging national industry is in fact just a "technological window" opened by the microcomputer revolution of the last few years, which is already corning to an end. The Brazilian computer industry relies on integrated circuits which are imported or produced locally by subsidiaries of multinational corporations. So far, it has been possible to produce reasonable clones of the Apple, TRS and even IBM PCs, through reverse engineering and the use of components available in the international market. Prices of Brazilian microcomputers are falling rapidly for 8-bit models, coming close to the international levels (this is not true, however, either for the IBM-PC compatibles or for peripherals such as monitors, disc-drives and printers). If, however, computers such as the Apple's Macintosh, based on dedicated and proprietary chips, represent the trend, the same pattern of imitation is considered impossible to maintain.

But who needs Macintosh? It has been argued that the Brazilian computer industry should not seek to emulate the American or Japanese patterns, but address itself to the country's actual needs. New products such as Macintosh respond to the conditions of competition of the American. market, and not necessarily to an existing demand or need. Seen from this light, the technological gap, although impossible to overcome, is not necessarily a reason to condemn the current policy of national self-reliance. There is, of course, an alternative reasoning, which is the notion that Macintosh represents the first major step of the computer industry into the mass consumption market, because of the direct access it provides to the non-professional user. If this is true, the consequences will be serious for a country which decides to stay away from this type of transformation.

What makes this question more complicated is how to define what the "national needs" are. In some areas, such as telecommunications, the "national need" has been defined as the interlinkage of all regions of the country, and of the country to the world through the most effective means, from telephones to satellites. This demand comes in part from large users of communication facilities, such as the TV networks, and in part from the drive of state-owned corporations working in the field, like EMBRATEL. In this area, there is a clear tendency to utilize only state-of-the-art technologies, and an obvious impatience with the limitations brought about by the current policy.

In other fields, such as banking, the need seems to be defined mostly by competition between firms. Brazil does not "need" 24-hour automatic tellers, or on-line services in the banks. In other countries, automatization of the banking system is essentially a labor-saving device. Given the low salaries paid in Brazil, and the high costs of the new technologies and its installation, it is doubtful that the motivation in Brazil is the same. Although it is clear that with the new technology changes in this labor force are bound to occur, with new skills becoming more important and others turning obsolete, this seems to be a consequence, rather than the reason for the changes.[16] Besides competition, the bank's entrance in the computer industry represents for them an important and profitable diversification.

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16 One explanation for the rapid entrance of Brazilian banks into automation are the profits derived from the speed of electronic funds transfers, which allow the banks to remain longer with the costumer' s resources and maximize their allocation. Another consequence of the current trend is the concentration of Brazil's banking system, with the elimination of those which cannot keep up with the automation race.

For SEI's new secretary, the current policy is irreversible, in spite of eventual adjustments. There are already too many interests involved, and great awareness of its need. He believes that the notion that there is an increasing technological gap between Brazil and other countries is mostly a myth He gives as an example the fact that the basic architecture and operational systems of large mainframes have not changed for many years, in spite of the development in chip integration. This stability is explained by the amount of capital and knowledge invested in established technologies which would be too costly to replace.[17] Since Brazil did not .make this previous investments, it could jump stages and work at the frontier. Brazil cannot compete in the market of highly integrated, mass produced chips, and could not work with too specialized products for small markets. Because of the country's size, however, there should be places for products of intermediate scale, for which there would be special comparative advantages. To find these advantages, or the "niches" the national companies could occupy, should be the basis of the whole policy. Examples would be "software plant project", the development of pace-makers for carriers of Chagas disease and a whole array of custom-made chips for medium-size markets, where large economies of scale are not feasible.

This policy can have its drawbacks. It excludes the two extremes of the computer market, the one dominated by mainframes and the large public which will eventually move into the massive utilization of microcomputers. For the former, access to international technology is open, and will probably continue to be so. Arrangements can also be made with local universities and research institutes to meet their needs. For the latter, however, the situation is more difficult. The problem is not just the availability and price of microcomputers, but the whole development of a user-oriented computer industry which is expanding so quickly in the advanced countries, but is badly lagging behind in Brazil. As this industry reaches the educational systems and the daily activities of small firms and independent professionals, there will be an increasing gap, not just towards foreign technology, but towards the whole computer culture that is emerging in the developed countries.

It is clear that the people responsible for PNI are not simple-minded nationalists determined to "reinvent the wheel". They may even talk, eventually, about "liberation technology" (after the famous Liberation Theology preached by many sectors of the Latin American Church) but are in fact looking for the special niches and opportunities the Brazilian computer industry can hope to occupy. The market reserve for microcomputers is only part of the whole strategy, which includes also a wide range of associations between Brazilian and foreign companies willing to share their technologies with its local counterparts. They were able to bring the question of computers and their utilization to the forefront, to develop national competence and stimulate the large multinational corporations to behave in a way they would probably not have done otherwise. Because of this policy, and because there are now sophisticated counterparts in Brazil, they are willing to talk about joint ventures, technological transfer, open technologies. Even IBM, which does not accept joint ventures, is competing for space in more positive (or at least more subtle) ways, through support to universities and technical assistance to local suppliers.

In all probability, PNI is not just a "window" opened with the Sinclair and Apple clones, to be closed with Macintosh. Given enough time and resources, Brazil will be able to build enough competence to attend to significant parts of its internal market, to find products it can export, to protect its local industry from foreign dumping and to reach reasonable standards of coexistence with international firms and international trends. There is, however, a race with time. Bureaucratic insulation can easily get sour: insolation can breed incompetence. And political clientelism, in a context of economic recession, can rapidly dismantle R&D capabilities built up through many years. Brazil is an open society, its integration with the international economy and

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17 In that sense, and contrary to common understanding, microelectronics and computing would be "mature technologies" like steel production of pharmaceutics before the introduction of genetics engineering.

culture is irreversible, and there will be increasing pressures from users not to be kept behind by inferior technologies, bad service, customs controls and industrial privileges. These pressures will be stimulated by foreign competitors, all too willing to demonstrate their presumed superiority and offer their services

In order not to lose this race, investments in R&D and computer education in Brazil will have to increase quite significantly, a bigger effort to look at the computer industry from the user 's point of view will have to be made, and a sophisticated view of the niches the Brazilian industries can occupy, in this complex and increasingly internationalized sector, will have to be kept at all times. It is possible to predict that, when the fad of computer games is over (as it is already in the United States and Europe) the future of the microcomputer sector will depend on the Brazilian capacity to compete with the applications and "friendliness" which is being developed elsewhere. An important switch will have to be made from the producer's to the individual user 's point of view, a change which is not nearly in sight. At the other extreme, Brazil is likely to continue to import large, sophisticated equipment for a long time. But, as the computer technology develops, the distinctions between "mini" "mid-size" and large computers tend to get blurred, and associations between Brazilian and foreign companies willing to share their technology will tend to increase. One can expect that, given appropriate support, these joint ventures will eventually branch out to both extremes of the computer industry, without necessarily destroying the purely national sector which is being developed under the umbrella of market protection.

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